UNITED STATES PATENT APPLICATION

METHOD AND APPARATUS TO PROVIDE AN AREA EFFICIENT ANTENNA DIVERSITY RECEIVER

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FIELD OF THE INVENTION

The invention relates generally to wireless communications and, more particularly, to radio frequency (RF) receivers.

BACKGROUND OF THE INVENTION

Antenna diversity receivers utilize two or more receive antennas to overcome reception problems caused by, for example, multipath fading. Each of the antennas typically requires a dedicated receiver chain to properly process a corresponding receive signal. The outputs of the receiver chains are then processed to generate the overall receiver output. Many modern receiver systems are required to operate within multiple different frequency bands. It may be desired, for example, that a cellular telephone be capable of operating in accordance with multiple different cellular standards that each have a different operational frequency range. Techniques and structures are therefore needed for efficiently implementing antenna diversity receivers, and other types of receivers, that are operative within multiple frequency ranges.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a block diagram illustrating an example dual antenna diversity receiver arrangement in accordance with an embodiment of the present invention; and

Fig. 2 is a flowchart illustrating an example method for use in an antenna diversity receiver system in accordance with an embodiment of the present invention.

DETAILED DESCRIPTION

In the following detailed description, reference is made to the accompanying drawings that show, by way of illustration, specific embodiments in which the invention may be practiced. These embodiments are described in sufficient detail to enable those skilled in the art to practice the invention. It is to be understood that the various embodiments of the invention, although different, are not necessarily mutually exclusive. For example, a particular feature, structure, or characteristic described herein in connection with one embodiment may be implemented within other embodiments without departing from the spirit and scope of the invention. In addition, it is to be understood that the location or arrangement of individual elements within each disclosed embodiment may be modified without departing from the spirit and scope of the invention. The following detailed description is, therefore, not to be taken in a limiting sense, and the scope of the present invention is defined only by the appended claims, appropriately interpreted, along with the full range of equivalents to which the claims are entitled. In the drawings, like numerals refer to the same or similar functionality throughout the several views.

Fig. 1 is a block diagram illustrating an example dual antenna diversity receiver arrangement 10 in accordance with an embodiment of the present invention. As illustrated, the receiver arrangement 10 includes: first and second antennas 12, 14; first and second selector switches 16, 18; first and second filter banks 20, 22; first, second, third, and fourth output switches 24, 26, 28, 30; and first, second, third, and fourth low noise amplifiers (LNAs) 32, 34, 36, 38. The first and second filter banks 20, 22 may each include multiple bandpass filters. For example, in the illustrated embodiment, the first filter bank 20 includes a first filter 40, a second filter 42, a third filter 44, and a fourth filter 46 and the second filter bank 22 includes a first filter 48, a second filter 50, a third filter 52, and a fourth filter 54. During normal operation, a signal is received by each of the antennas 12, 14 and the signal is then directed through one of the corresponding filters and one of the corresponding LNAs. The outputs of the LNAs are then processed in a known manner to achieve the overall output of the dual antenna diversity receiver. The first antenna 12 and its corresponding circuitry may represent

the primary receive channel of the dual antenna diversity receiver arrangement 10 and the second antenna 14 and its corresponding circuitry may represent the secondary receive channel. Although illustrated as a dual antenna diversity arrangement, it should be appreciated that additional receive channels may also be provided in accordance with the invention.

In at least one embodiment, each filter within a filter bank corresponds to a particular operational frequency band within which the receiver arrangement 10 is to operate. For example, in one possible implementation, the first filter 40, 48 within each filter bank 20, 22 may be operative within the 850 Global System for Mobile Communications (GSM) band (i.e., 869 MHz to 894 MHz), the second filter 42, 50 within the Enhanced Global System for Mobile Communications (EGSM) band (i.e., 925 MHz to 960 MHz), the third filter 44, 52 within the Digital Communication System (DCS) 1800 band (i.e., 1805 MHz to 1880 MHz), and the fourth filter 46, 54 within the Personal Communication System (PCS) 1900 band (i.e., 1930 MHz to 1990 MHz). Many alternative arrangements also exist. The number of filters within each filter bank and the type and number of frequency bands covered may vary from implementation to implementation.

The first and second selector switches 16, 18 are each operative for controllably coupling a corresponding antenna 12, 14 to the input of one of the filters within the corresponding filter bank 20, 22. In at least one embodiment, the first and second selector switches 16, 18 operate in a synchronized fashion so that the first and second antennas 12, 14 are each coupled to filters associated with the same frequency range during receiver operation. For example, if operation within a first frequency band (e.g., the GSM band) is desired, the first selector switch 16 may couple the first antenna 12 to the first filter 40 within the first filter bank 20 while the second selector switch 18 couples the second antenna 14 to the first filter 48 within the second filter bank 22. Similarly, if operation within another frequency band (e.g., the DCS 1800 band) is desired, the first selector switch 16 may couple the first antenna 12 to the third filter 44 within the first filter bank 20 while the second selector switch 18 couples the second antenna 14 to the third filter 52 within the second filter bank 22, and so on. Other

control arrangements may alternatively be used. Any type of filters may be used within the filter banks 20, 22 including, for example, surface acoustic wave (SAW) filters, film bulk acoustic resonator (FBAR) filters, microstrip and/or stripline filters (typically at higher frequencies due to size constraints), and others, including combinations of different types of filter.

The LNAs 32, 34, 36, 38 within the receiver arrangement 10 may each be shared by two or more of the filters within the corresponding filter bank 20, 22. For example, in the illustrated embodiment, LNA 32 is shared by filters 40 and 42 within filter bank 20, LNA 34 is shared by filters 44 and 46 within filter bank 20, LNA 36 is shared by filters 48 and 50 within filter bank 22, and LNA 38 is shared by filters 52 and 54 within filter bank 22. Each of the output switches 24, 26, 28, 30 is operative for selectively coupling the output of one of its associated filters to the input of a corresponding LNA. Each LNA will typically be operational within the bandpass frequency ranges of all of its corresponding filters (e.g., LNA 32 should be operational within the bandpass frequency ranges of filter 40 and filter 42, etc.). In at least one embodiment, the output switches 24, 26, 28, 30 operate in synchronism with the selector switches 16, 18. The number of LNAs and the number of output switches associated with each antenna may vary from implementation to implementation. For example, with reference to Fig. 1, the two LNAs 32, 34 associated with antenna 12 may be replaced by a single LNA and the two output switches 24, 26 may be replaced by a single four-to-one output switch. Similar changes may also be made in connection with antenna 14. One or more filters may also be directly connected to the input of a corresponding LNA in accordance with the invention. As will be appreciated, many other modifications may be made to the illustrated structures in accordance with the invention.

By allowing at least one LNA associated with an antenna to be shared by two or more filters, the overall size of the receiver may be reduced considerably. The receiver can thus be implemented within a much smaller area on a semiconductor chip than would be possible if each frequency band had a dedicated LNA for each antenna. The addition of output switches may tend to reduce the sensitivity of an antenna diversity receiver (or, for that matter, a non-antenna diversity receiver). However, the reduction

in circuit size that can be achieved by practicing LNA sharing may be considered more desirable than the greater sensitivity that may be available by not practicing it. Typically, the increase in sensitivity achieved by implementing antenna diversity will be significantly larger than the reduction in sensitivity caused by the addition of output switches. Thus, a larger amount of receiver sensitivity improvement may be achieved by switching to antenna diversity and then some of that improvement may be traded off to achieve smaller size by implementing LNA sharing.

With reference to Fig. 1, in at least one embodiment of the present invention, the selector switches, the filters, and the output switches are implemented within a single filter/switch module 56 and the LNAs are implemented as part of a separate radio frequency integrated circuit (RFIC) 58. In addition to the LNAs, the RFIC 58 may also include other receiver circuitry for processing the receive signals. In some other embodiments, the selector switches, the filters, the output switches, and the LNAs are implemented on a single RFIC. Many alternative configurations also exist. In at least one embodiment, the antennas 12, 14 (and the antenna terminals 60, 62) are implemented on the same chip or substrate as the selector switches 16, 18 (e.g., as microstrip patch elements or some other element type). Any form of antenna may be used in accordance with the present invention including, for example, dipoles, patches, helixes, arrays, and/or others. Combinations of different types of antenna elements may also be used.

To achieve a further reduction in receiver size on a semiconductor chip, the secondary receive channel (and any additional receive channels) may utilize lower performance components than the primary receive channel. In addition, a lower performance antenna may also be used for the secondary channel and any additional channels. However, the use of lower performance components in one or more receive channels is not required. In at least one scenario, it may be desired that a dual antenna diversity receiver also be capable of receiving two different channels simultaneously (i.e., one through each antenna). In such a case, it may be desirable to utilize high performance components in all receive channels.

In at least one embodiment of the present invention, a handheld communicator is provided that incorporates features of the present invention. The handheld communicator may include, for example, a cellular telephone or the like. The handheld communicator may be configured for use in accordance with any of a number of different communication standards including, for example, Global System for Mobile Communications (GSM), General Packet Radio Service (GPRS), Enhanced Data for GSM Evolution (EDGE), and/or others.

Fig. 2 is a flowchart illustrating an example method 70 for use in an antenna diversity receiver system in accordance with an embodiment of the present invention. The antenna diversity receiver system will have at least first and second antennas and each antenna will have at least two corresponding bandpass filters. When receiver operation within a first frequency band is desired, the first antenna is coupled to the input of a first bandpass filter and the output of the first bandpass filter is coupled to the input of a first LNA (block 72). This coupling may be performed by, for example, sending a control signal to an appropriate switch. When receiver operation within a second frequency band is desired, the first antenna is coupled to the input of a second bandpass filter and the output of the second bandpass filter is coupled to the input of the first LNA (block 74). In this manner, the first and second bandpass filter (and possibly other bandpass filters) may share the first LNA. A similar procedure may be followed with respect to the other antenna(s) within the system. The above described method may be expanded for use in receivers supporting any number of different frequency bands. For example, in a receiver that is operative within four frequency bands, when operation within a third frequency band is desired, the first antenna may be coupled to the input of a third bandpass filter and the output of the third bandpass filter may be coupled to the input of a second LNA (or, in another embodiment, to the input of the first LNA). Similarly, if operation within the fourth frequency band is desired, the first antenna may be coupled to the input of a fourth bandpass filter and the output of the fourth bandpass filter may be coupled to the input of the second LNA (or, in another embodiment, to the input of the first LNA). Again, a similar procedure may be followed with respect to the other antenna(s) within the system.

In the foregoing detailed description, various features of the invention are grouped together in one or more individual embodiments for the purpose of streamlining the disclosure. This method of disclosure is not to be interpreted as reflecting an intention that the claimed invention requires more features than are expressly recited in each claim. Rather, as the following claims reflect, inventive aspects may lie in less than all features of each disclosed embodiment.

Although the present invention has been described in conjunction with certain embodiments, it is to be understood that modifications and variations may be resorted to without departing from the spirit and scope of the invention as those skilled in the art readily understand. Such modifications and variations are considered to be within the purview and scope of the invention and the appended claims.